CHAPTER VI AQUATIC ECOLOGY

A variety of aquatic organisms representing various trophic levels from the lowly bacteria to predatory fish naturally inhabit lakes and ponds. This study focused on the microscopic planktonic algae because of its relationship to phosphorus loading and eutrophication. Increased phosphorus levels in a lake generally result in increased algal growth. Both the types of algae and the amount of algae (as measured by chlorophyll-a) is reported. Because increased algal growth in a lake can decrease the water clarity or transparency of the water, we also report on water transparency in this section. Finally, information on macrophytes (rooted aquatic plants) and zooplankton (microscopic planktonic animals) is reported.

A. PHYTOPLANKTON

Phytoplankton are microscopic algae that live in the sunlit portions of the water column and move with the water currents. Types of net phytoplankton, which are phytoplankton collected in an 80 micron mesh sampling net, that were dominant during the year are reported. Table VI-1 lists the dominant phytoplankton along with the percent abundance, and the raw phytoplankton data is presented in Appendix VI-1.

Seasonal succession is the term used to describe the changes in phytoplankton population dominance at different times of the year. In general, these changes are believed to be the result of the organism's response to changing light, temperature and nutrient conditions, and also the result of zooplankton grazing. Different types of phytoplankton are suited to different conditions and become dominant when those conditions prevail.

The phytoplankton data demonstrates little difference between the two stations during the year and the subsequent discussion refers to the lake in general.

The diatom *Asterionella* was the dominant phytoplankton during the fall, winter and spring months. Other diatoms (*Rhizosolenia and Tabellaria*) were the second most dominant plankton in the fall while the chrysophyte *Dinobryon* was the second dominant in winter and spring. *Asterionella* and *Dinobryon* are very common plankton in New Hampshire lakes. Two-thirds of the state's lakes have one or the other dominant during the winter months (NHDES,

Table VI-1
Great Pond Net Phytoplankton
Percent Dominance, October 1994 through October 1995

Date	Station	Dominant Net Phytoplankton	% of Total	Date	Station	Dominant Net Phytoplankton	% of Total
10/25/94	North	Asterionella	48	05/12/95	North	Asterionella	95
		Rhizosolenia	14		South	Asterionella	97
		Coelosphaerium	13	05/25/95	North	Asterionella	95
	South	Asterionella	55		South	Asterionella	81
		Tabellaria	12			Anabaena	14
		Synura	11	06/07/95	North	Asterionella	71
11/14/94	North	Asterionella	61			Dinobryon	13
		Rhizosolenia	18			Asterionella	82
		Tabellaria	10	06/14/95	North	Dinobryon	44
	South	Asterionella	61			Asterionella	42
		Tabellaria	21		South	Asterionella	49
		Microcystis	6			Dinobryon	30
12/06/94	North	Asterionella	88	06/21/95	North	Dinobryon	44
		Rhizosolenia	10			Asterionella	19
	South	Asterionella	92			Anabaena	17
01/30/95	North	Asterionella	85		South	Anabaena	31
	South	Asterionella	83			Dinobryon	25
02/16/95	North	Asterionella	71			Asterionella	16
		Dinobryon	28	06/28/95	North	Dinobryon	27
	South	Asterionella	85			Asterionella	23
		Dinobryon	10			Anabaena	23

03/09/95	North	Asterionella	77		South	Dinobryon	37
		Dinobryon	23			Anabaena	20
	South	Asterionella	93			Synura	17
04/17/95	North	Asterionella	89	07/05/95	North	Synura	45
	South	Asterionella	86			Dinobryon	27
		Dinobryon	17			Anabaena	19

Table VI-1 (Cont.)
Great Pond Net Phytoplankton
Percent Dominance and Densities, October 1994 through November 1995

Date	Station	Dominant Net Phytoplankton	% of Total	Date	Station	Dominant Net Phytoplankton	% of Total
07/05/95	South	Dinobryon	69	08/14/95	North	Microcystis	34
		Synura	12			Ceratium	28
		Asterionella	10		South	Microcystis	44
07/12/95	North	Synura	60			Ceratium	28
		Dinobryon	35	08/23/95	North	Microcystis	52
	South	Dinobryon	54			Ceratium	25
		Synura	36		South	Microcystis	64
07/17/95	North	Dinobryon	87			Ceratium	16
	South	Dinobryon	77	08/30/95	North	Ceratium	33
07/26/95	North	Dinobryon	74			Chrysosphaerella	27
	South	Dinobryon	27			Microcystis	26
		Mallomonas	22		South	Microcystis	37

		Sphaerocystis	12			Chrysosphaerella	31
08/02/95	North	Dinobryon	44	09/05/95	North	Chrysosphaerella	45
		Ceratium	21			Ceratium	24
	South	Oscillatoria	17			Microcystis	12
		Ceratium	17		South	Chrysosphaerella	62
		Dinobryon	17			Microcystis	19
08/09/95	North	Microcystis	43	09/15/95	North	Asterionella	30
		Ceratium	28			Microcystis	21
	South	Oscillatoria	32			Oscillatoria	15
		Microcystis	29	10/20/95	North	Asterionella	62
					South	Asterionella	66

Group Divisions:

Diatoms	Blue-Greens	Dinoflagellates	Golden-Brown Flagellated
Asterionella	Anabaena	Ceratium	Chrysosphaerella
Rhizosolenia	Coelosphaerium		Dinobryon
Tabellaria	Microsystis		Synura
	Oscillatoria		Mallomonas

1997). *Asterionella* in particular seems to be well suited to the low light, cold water conditions of winter and is a common winter dominant in all trophic classes of lakes.

During early to mid summer *Dinobryon* and *Synura* became dominant, and we began to see the bluegreen alga *Anabaena* appear in substantial numbers. By late summer the bluegreens *Oscillatoria* and *Microcystis* became the dominant algae. In lakes that have summer bluegreen algal populations it is not unusual for New Hampshire lakes (e.g., Frost, et al., 1976) or for other north temperate lakes (e.g., Fogg, et al., 1973) to have *Anabaena* as the first bluegreen species to appear, followed by other bluegreen species. In New Hampshire the succeeding bluegreen is frequently *Aphanizomenon* or *Gloeotrichia* under high nutrient conditions and *Microcystis* under moderate nutrient levels.

Ceratium and later *Chrysosphaerella* were frequently the second dominants during the late summer period. These along with other chrysophyte species are common dominants in tea-colored ponds of New Hampshire.

By fall *Asterionella* once again resumed its position of dominance. In general the succession of phytoplankton in Great Pond was typical of a tea-colored, moderately enriched pond in New Hampshire.

B. ZOOPLANKTON

Zooplankton are microscopic planktonic animals in waterbodies that feed on microscopic algae. The species of zooplankton present generally do not reflect a specific trophic state but, as the next step in the food chain above the algae, their numbers can be an indirect measure of lake productivity. The dominant zooplankton for both lake stations on each sampling date are listed in Table VI-2, along with the total number of zooplankton for each date. The yearly mean density of zooplankton groups is listed in Table VI-3. Appendix VI-2 presents the raw zooplankton data. From March to August zooplankton were checked for presence but counts were not made and therefore percent abundances could not be calculated.

Again there was little overall difference in zooplankton between the two stations although the order of the top two or three dominants varied between stations. This is expected based on the patchiness of plankton distributions and the sensitivity of the analytical procedure. In general the zooplankton was dominated by the rotifers *Polyarthra* and *Keratella* and by the crustaceans

Table VI-2

Great Pond Zooplankton Dominance and Densities

October 1994 through October 1995

Date	Station	Species	Rel. % Abund.	Tot. Zoo Cells/L
10/25/94	NORTH	POLYARTHRA CALANOID COPEPOD KERATELLA	24.0 18.0 14.0	109.0
10/25/94	SOUTH	POLYARTHRA KERATELLA	29.0 16.0	82.8
11/14/94	NORTH	BOSMINA DAPHNIA POLYARTHRA	35.0 15.0 13.0	117.7
11/14/94	SOUTH	KERATELLA DAPHNIA BOSMINA	32.0 26.0 21.0	41.4
12/6/94	NORTH	POLYARTHRA BOSMINA KERATELLA	28.0 28.0 17.0	141.7
12/6/94	SOUTH	DAPHNIA POLYARTHRA BOSMINA	33.0 16.0 16.0	39.2
1/30/95	NORTH	KERATELLA KELLICOTTIA	38.0 23.0	93.6
1/30/95	SOUTH	POLYARTHRA KERATELLA	44.0 18.5	97.2
2/16/95	NORTH	POLYARTHRA NAUPLIUS LARVA KERATELLA	36.0 18.0 13.0	222.4
2/16/95	SOUTH	NAUPLIUS LARVA CALANOID COPEPOD	42.0 14.0	128.6
8/9/95	NORTH	POLYARTHRA DAPHNIA ACTINOPHRYS	28.9 17.8 15.6	98.1
8/9/95	SOUTH	ACTINOPHRYS POLYARTHRA NAUPLIUS LARVA	51.8 15.7 12.0	180.9

Table VI-2 (cont.)

Great Pond Zooplankton Dominance and Densities

October 1994 through October 1995

Date	Station	Species	Rel. % Abund.	Tot. Zoo Cells/L
8/14/95	NORTH	KELLICOTTIA NAUPLIUS LARVA ACTINOPHRYS	25.0 19.6 17.9	122.1
8/14/95	SOUTH	NAUPLIUS LARVA KELLICOTTIA CYCLOPOID COPEPOD	32.1 28.7 16.1	189.7
8/23/95	NORTH	ACTINOPHRYS NAUPLIUS LARVA KELLICOTTIA	27.3 18.2 15.2	71.9
8/23/95	SOUTH	ACTINOPHRYS CALANOID COPEPOD NAUPLIUS LARVA	44.4 13.9 11.1	71.9
8/30/95	NORTH	KELLICOTTIA DAPHNIA ACTINOPHRYS	25.0 21.9 15.6	69.8
8/30/95	SOUTH	NAUPLIUS LARVA KELLICOTTIA ACTINOPHRYS	32.8 29.5 13.1	133
9/5/95	NORTH	NAUPLIUS LARVA KELLICOTTIA POLYARTHRA	26.5 25.0 16.2	148.2
9/5/95	SOUTH	KELLICOTTIA NAUPLIUS LARVA ACTINOPHRYS	23.4 19.1 14.9	102.5
9/15/95	NORTH	POLYARTHRA KELLICOTTIA NAUPLIUS	27.5 15.0 15.0	87.2
10/20/95	SOUTH	KERATELLA CALANOID POLYARTHRA	28.0 26.0 17.0	

Daphnia, Bosmina and calanoid copepods, including their nauplius larval form. There was no seasonal succession of zooplankton although the actinopod protozoan *Actinophrys* was present in abundance only during the late summer months.

The dominant genus of zooplankton was more often a rotifer that a crustacean although, in terms of total rotifers and total crustaceans, each group dominated essentially the same number of times.

Looking at summer data only (Table VI-4), the crustaceans were slightly more dominant that the rotifers.

Table VI-3

Rotifer and Crustacean Mean Densities for

Great Pond North, Great Pond South and New Hampshire

Site	Mean Rotifer Density (#/L)	Mean Crustacean Density (#/L)
Great Pond (North)	54.9	53.2
Great Pond (South)	36.9	45.3
N.H. Lakes	192.0	94.00

Table VI-4 provides zooplankton mean summer densities along with suggested ranges for the three trophic classes. Both rotifers and total zooplankton counts place Great Pond in the mesotrophic range while crustacean counts indicate eutrophic. A new analysis of New Hampshire crustacean zooplankton, however, indicate that the densities in Great Pond are very typical of mestrophic waters. In any case the trophic ranges given are very general and there is a wide range of zooplankton densities in all trophic classes.

In summary the zooplankton types and densities observed in Great Pond were very typical of a moderately enriched New Hampshire lake.

Table VI-4

Great Pond Mean Summer Zooplankton Densities (cells/L)

	Rotifers	Crustaceans	Total Zooplankton
Great Pond - North	35	39	90
Great Pond - South	48	59	144
Oligotrophic	0-10	0-1	0-50

Mesotrophic	10-250	1-25	50-250
Eutrophic	>250	>25	>250

C. CHLOROPHYLL -A AND TRANSPARENCY

All plants have chlorophyll-a as well as other pigments that allow them to convert energy from the sun into organic matter through photosynthesis. The chlorophyll-a analysis is an indirect measure of the biomass or amount of planktonic algae in the water - including both the net phytoplankton and the smaller phytoplankton. Transparency as measured with a Secchi disk is a measure of water clarity. Water clarity is affected by suspended matter in the water, both living and dead, and by the color of the water. Except in special situations where silt or other non-living turbidity is present, there is a direct relationship between transparency and algal biomass (chlorophyll). As chlorophyll increases, transparency decreases.

Table VI-5 portrays mean monthly chlorophyll and transparency data for the two Great Pond stations, while the raw data is listed in Appendix VI-3. Data from the two stations was very similar. In general, chlorophyll values were less than 4 mg/m3 for fall and spring and ranged from 4 to 6 mg/m3 during the summer (no winter values were measured). Transparency values ranged from 3 to 4 meters throughout the year (again no winter measurements).

Summer chlorophyll and transparency values are good measures of lake trophic state. Generally as a lake becomes more eutrophic (higher phosphorus concentrations), the chlorophyll increases and the transparency decreases. Both chlorophyll and transparency values for Great Pond indicate a mesotrophic condition (see Table VI-6), but close to the oligotrophic/mesotrophic boundary.

Although there is a distinct, non-linear inverse relationship between chlorophyll and transparency (see discussion by Edmondson, 1972), this relationship is distinct only when there is a wide range in chlorophyll values (e.g., <1 to 50 mg/m3). In the narrow range observed in Great Pond (<1 to 11 with most values in the 3 to 5 mg/m3 range) the natural scatter of the data points obscures any relationship. A statistical analysis of the data revealed no correlation or relationship between chlorophyll and transparency in Great Pond. The fact that water clarity remained essentially the same during the fall when chlorophyll was at its minimum suggests that water color and/or non-living suspended matter may have some affect on water clarity. In summary, summer chlorophyll and transparency values at Great Pond were typical of a mesotrophic (borderline oligotrophic) New Hampshire lake. Management implications of the non-relationship between chlorophyll and transparency, and specifically the fact that transparency remained constant even when chlorophyll decreased in the fall, are that efforts to reduce phosphorus inputs and algal growth may have little impact on water transparency.

Table VI-5

Great Pond Monthly Mean Chlorophyll-a and Transparency

October 1994 through October 1995

Month/Year	North		South	
	Chlorophyll-a (mg/m^3)	Transparency (m)	Chlorophyll-a (mg/m^3)	Transparency (m)
October 1994	2.89	4.0	2.37	4.1
November 1994	-	3.3	-	3.6
December 1994	<1	3.3	<1	3.2
January 1995	-	-	-	-
February 1995	-	-	-	-
March 1995	-	-	-	-
April 1995	3.10	3.2	2.92	3.1
May 1995	5.54	3.0	5.66	3.0
June 1995	5.38	3.2	5.16	3.2
July 1995	5.32	4.0	6.88	4.0
August 1995	4.63	3.7	3.69	3.6
September 1995	5.02	3.1	4.02	3.7
October 1995	1.85	2.9	2.18	3.3

Table VI-6

Great Pond Mean Summer Chlorophyll-a and Transparency

	Chlorophyll-a (mg/m^3)	Transparency (m)
Great Pond - North	4.93	3.9
Great Pond - South	5.10	3.8
Oligotrophic	0-4	>4
Mesotrophic	4-15	1.8-4
Eutrophic	>15	<1.8

D. AQUATIC VEGETATION

The aquatic plants that grow along the shores of lakes and ponds are variously referred to as aquatic macrophytes, rooted vascular aquatic plants or weeds. The presence and abundance of rooted plants in lakes is primarily determined by water depth and clarity, substrate type and wind and wave action. Most rooted aquatic plants receive most if not all of their nutrient needs from the bottom substrate through their roots. Increasing the phosphorus supply to a lake does not necessarily result in increased macrophyte growth - at least not initially (over time some of this increased phosphorus will be deposited in the sediment and may support future plant growth).

If trophic state is used as it was originally defined to mean “nutrient status”, then macrophyte growth is not a measure trophic state. However, if trophic state is defined as the biological productivity that occurs in a lake (as DES defines it), then plant abundance does indicate trophic state.

The location, density and type of macrophyte growth in Great Pond is portrayed in Figure VI-1, with Table VI-7 providing the key to the plant letters. Plant growth was very common around the entire shoreline of the lake and around the island. A grouping of emergent and floating leaf plants were also present in the open water but shallow area located in the southwestern portion of the pond. The non-rooted plant bladderwort was the most abundant plant, with lilies also being listed as relatively common. Although not shown on the map, wetlands abut some of the lake's shoreline, particularly along the inlet located at the southwest end and along the two inlets at the northern end.

Macrophyte growth in Great Pond was typical of a mesotrophic New Hampshire lake. The plants observed are all plants commonly found in New Hampshire waters. No exotic or non-native plants were found. Although plant growth may be a nuisance to the person who wants a plant-free sandy beach, plants are important for a balanced, healthy lake ecosystem. They provide food and habitat for a variety of organisms and help control erosion and flooding.

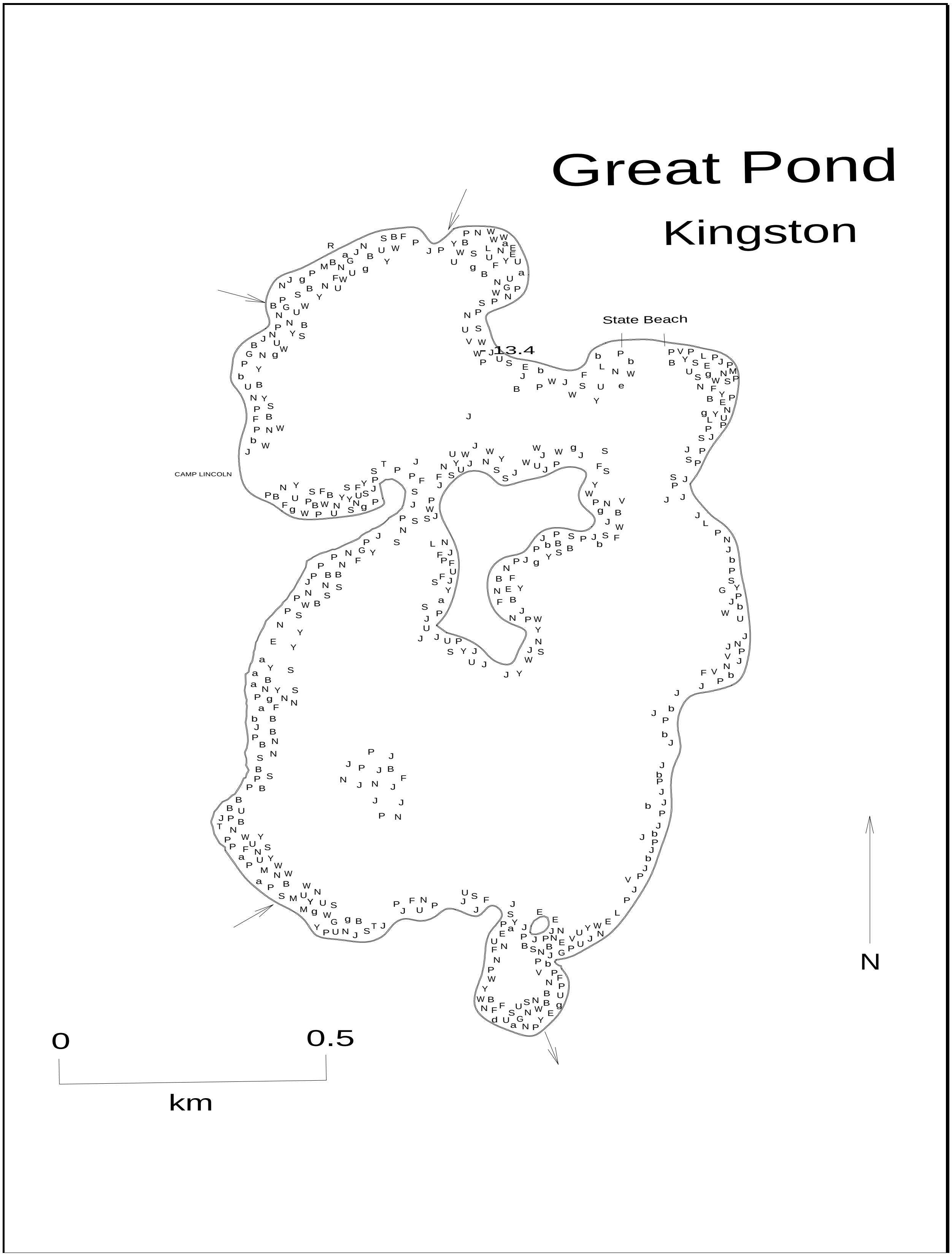
Great Pond
Kingston
State Beach
13.4
CAMP LINCOLN
N
0
0.5
km

Table VI-7

Great Pond Aquatic Plant Map Key, 1995

AQUATIC PLANT SURVEY			
Lake: Great Pond	**Town: Kingston**		**Date: 07/20/95**
Mapcode	**Plant Name**		**Abundance**
	Species	**Common**	
N	Nymphaea	White water lily	Scattered/Common
Y	Nuphar	Yellow water lily	Scattered/Common
P	Pontederia cordata	Pickerelweed	Scattered
S	Sparseganium	Bur reed	Scattered
J	Juncus	Rush	Scattered
U	Utricularia	Bladderwort	Common
L	Lobelia dortmanna	Water lobelia	Scattered
E	Eriocaulon septangulare	Pipewort	Scattered
F	Nymphoides cordatum	Floating heart	Scattered
e	Elodea nuttallii	Waterweed	Sparse
b	Scirpus	Bulrush	Sparse
W	Potamogeton	Pondweed	Sparse
B	Brasenia schreberi	Water shield	Sparse
V	Vallisneria americana	Tape grass	Sparse
G	Gramineae	Grass family	Sparse

g	Cyperaceae	Non-flowering sedge	Sparse
a	Peltandra virginica	Arrow arum	Sparse
A	Sagittaria	Arrowhead	Sparse
m	Megalodonta Beckii	Water marigold	Sparse
R	Phragmites Commonunis	Reed grass	Sparse
d	Dulichium arundinaceum	Three-way sedge	Sparse
T	Typha	Cattail	Sparse
OVERALL ABUNDANCE: Common/Abundant			